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Environmental Radiation Monitoring

Barbara C. Fields

Introduction

A variety of radioisotopes are used at LLNL for biomedical, general, and nuclear weapons research. These include transuranics, tritium, and mixed fission products. In accordance with federal regulations, DOE Orders 5400.1 and 5400.5, and Title 17, California Code of Regulations, Section 30250, LLNL monitors direct gamma radiation to establish background radiation levels in its vicinity and to determine the direct environmental radiological impact of its operations. Gamma radiation results from natural background sources of terrestrial or cosmic origin and from man-made sources, such as fallout from past nuclear weapons testing and any contribution from LLNL operations.

Because environmental radiological monitoring is used as one measure of the potential direct radiation dose the public receives as the result of LLNL operations, LLNL has developed an extensive radiological monitoring network for the Livermore site perimeter, the Livermore Valley, and the Site 300 perimeter. Direct gamma radiation has been measured at the Livermore site since 1973, and a direct environmental radiation monitoring program was implemented at Site 300 in 1988. Direct gamma radiation is measured using thermoluminescent dosimeters (TLDs), which provide a measure of the total amount of gamma radiation at a particular location. Environmental neutron monitoring, which was also started in 1973, was discontinued at the end of 1994. Currently, environmental exposure to neutrons is not a concern at LLNL. However, should it become necessary for LLNL to start up operations that produce neutrons at significant levels, environmental neutron monitoring can be resumed. As a result of a gamma network assessment, the number of monitoring locations was reduced in 1995 (Harrach et al. 1996).

Monitoring Locations

External doses from direct gamma radiation were monitored at 14 Livermore site perimeter locations (shown in **Figure 11-1**), and 23 Livermore Valley locations (**Figure 11-2**) in 1996. These off-site locations are used for background comparison with perimeter locations. Similarly, gamma doses were monitored at nine perimeter monitoring locations at Site 300 (**Figure 11-3**), 5 in areas near Site 300, and 2 locations in

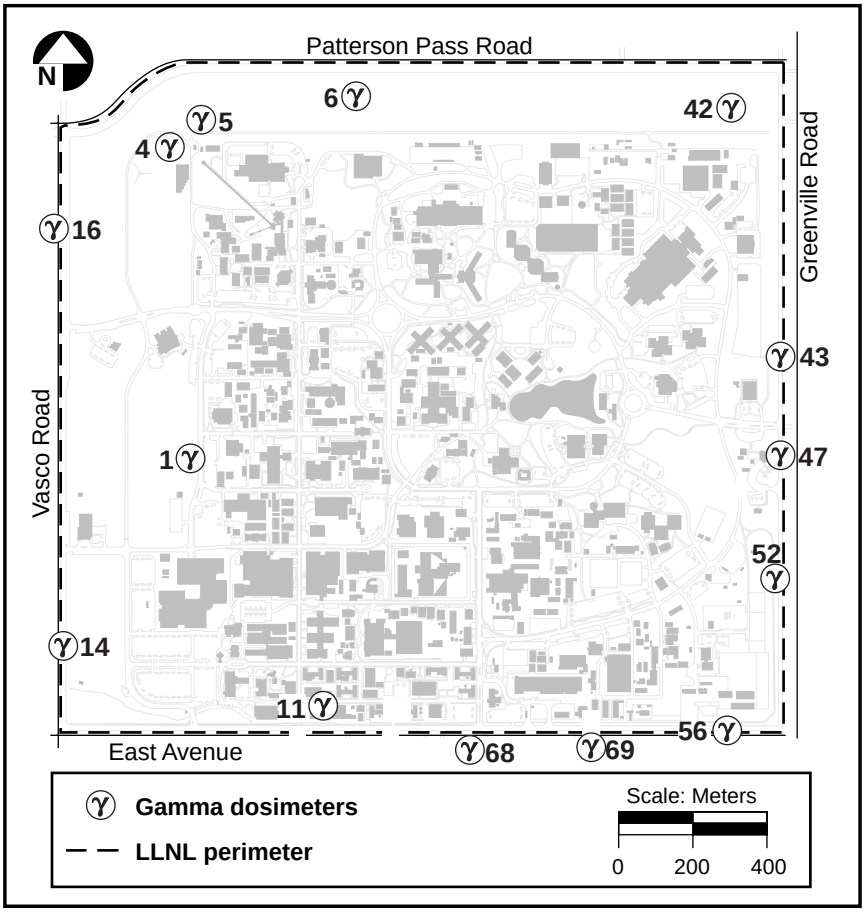

Figure 11-1. Gamma dosimeter locations, Livermore site, 1996.

nearby Tracy. Six monitoring locations near Site 300 were added as part of a special study in 1993. Monitoring has continued at these locations to provide data from areas not likely to be affected by LLNL operations. Sampling at locations 84 and 95 (Harrach et al. 1996) was discontinued in 1996.

Results of Gamma Monitoring

In 1995, all of the quarterly gamma radiation data points were normalized to standard 90-day quarters, as is the practice of the Nuclear Regulatory Commission (NRC) (Struckmeyer 1994). This practice was continued in the 1996 data processing and analyses. By using the same standard-quarter reporting method, data from other DOE and NRC facilities and data from intercomparison studies can be more easily compared. As shown in **Figure 11-4**, when our data are adjusted to standard quarters, the variability in exposures that was previously reported (Harrach et al. 1995) is reduced.

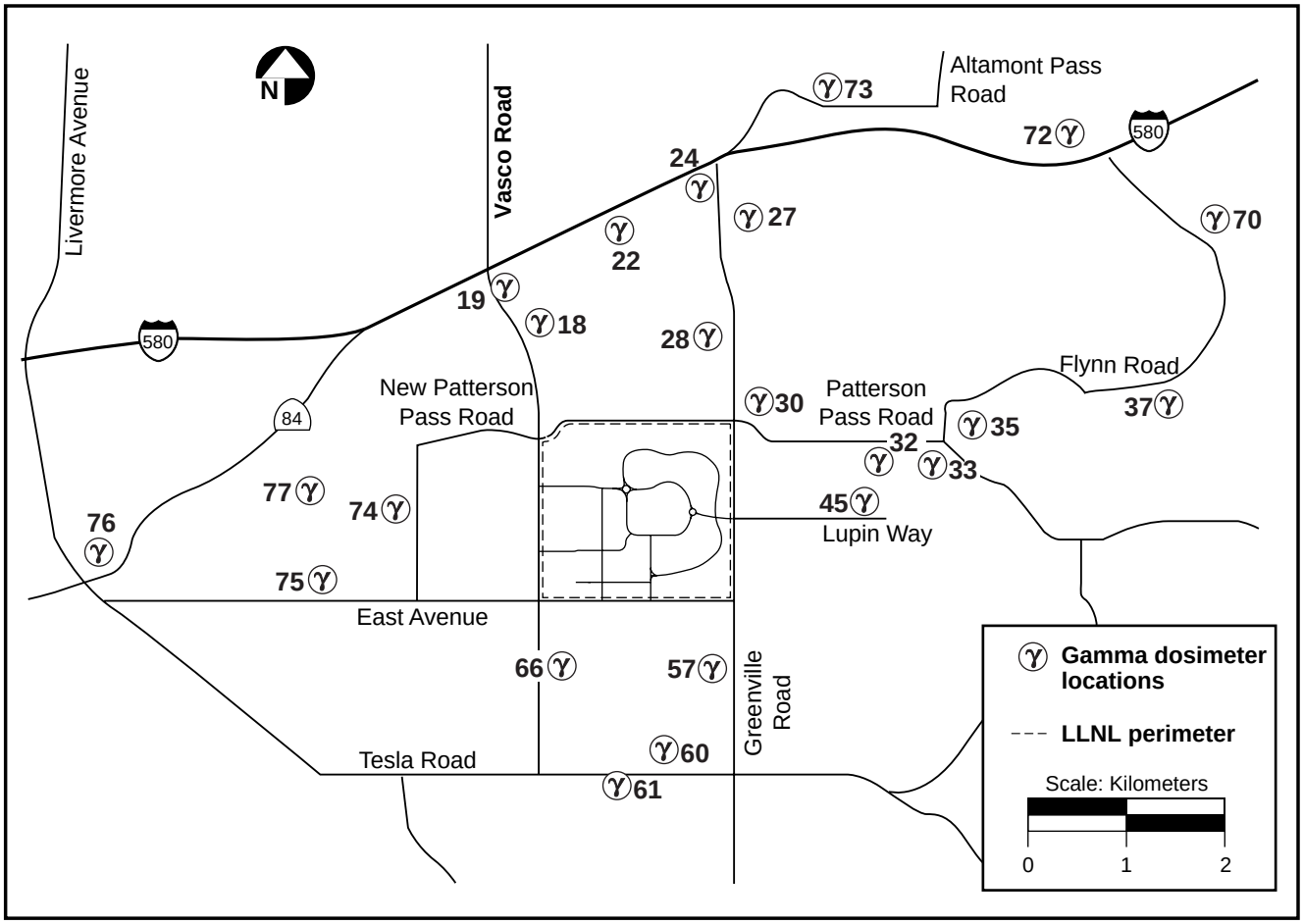

Figure 11-2. Gamma dosimeter locations, Livermore Valley, 1996.

Livermore Site

Table 11-1 presents a summary of the quarterly and annual TLD gamma radiation dose equivalents for the Livermore site perimeter locations and Livermore Valley off-site locations. The mean 1996 dose equivalent from external direct radiation exposure at the Livermore site perimeter, 0.55 mSv (55 mrem), is about the same as background external dose measured in the Livermore Valley, 0.55 mSv (55 mrem). **Table 11-2** lists the yearly doses due to direct gamma radiation at the LLNL site perimeter. The data, normalized to 90-day standard quarters, show no significant variation from year to year.
Figure 11-5 presents the frequency distribution for external radiation dose measured at 23 Livermore Valley locations. See Chapter 11, Volume 2, of this report for a discussion of methods and more comprehensive presentation of the data.

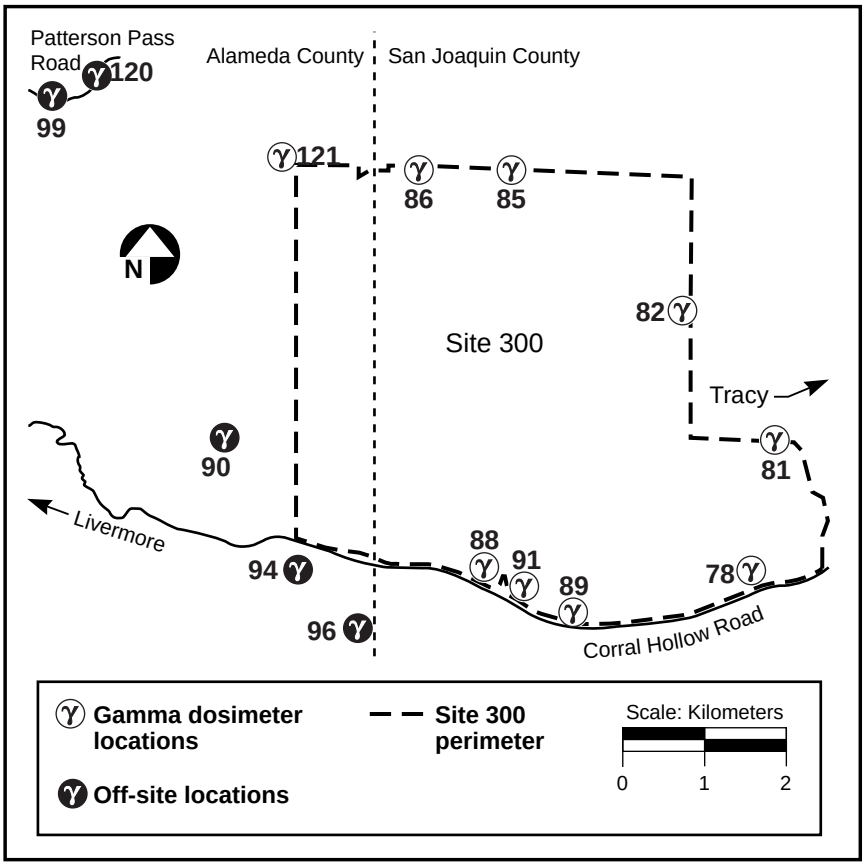

Figure 11-3. Gamma dosimeter locations, Site 300 and vicinity, 1996.

Site 300

As seen in **Table 11-1**, the measured Site 300 perimeter average dose in 1996 was 0.66 mSv (66 mrem), the measured dose at the off-site locations near Site 300 was 0.71 mSv (71 mrem), and the measured doses in and near Tracy were 0.63 mSv (63 mrem). All doses are within the predicted range for background radiation, and no LLNL operational impacts are discernible.

At Site 300, the initial TLD network design limited monitoring to the Site 300 perimeter and two locations in and near the city of Tracy, which were chosen to represent background radiation levels. However, the Tracy locations are located on a geological substrate different from that at Site 300. The region around Site 300 has higher levels of naturally occurring uranium, which is present in the Neroly Formation. The mean dose measured in the off-site locations of the area around Site 300, which is used to represent the high end of background radiation from this formation, was 0.71 mSv (71 mrem) and is greater than the Site 300 perimeter dose of 0.66 mSv (66 mrem). The Tracy area, with a dose of 0.63 mSv (63 mrem), is at a lower elevation, with geological constituents

composed of alluvial deposits of clays, sands, and silts overlying the bedrock. The difference in doses can be directly attributed to the difference in geologic substrates.

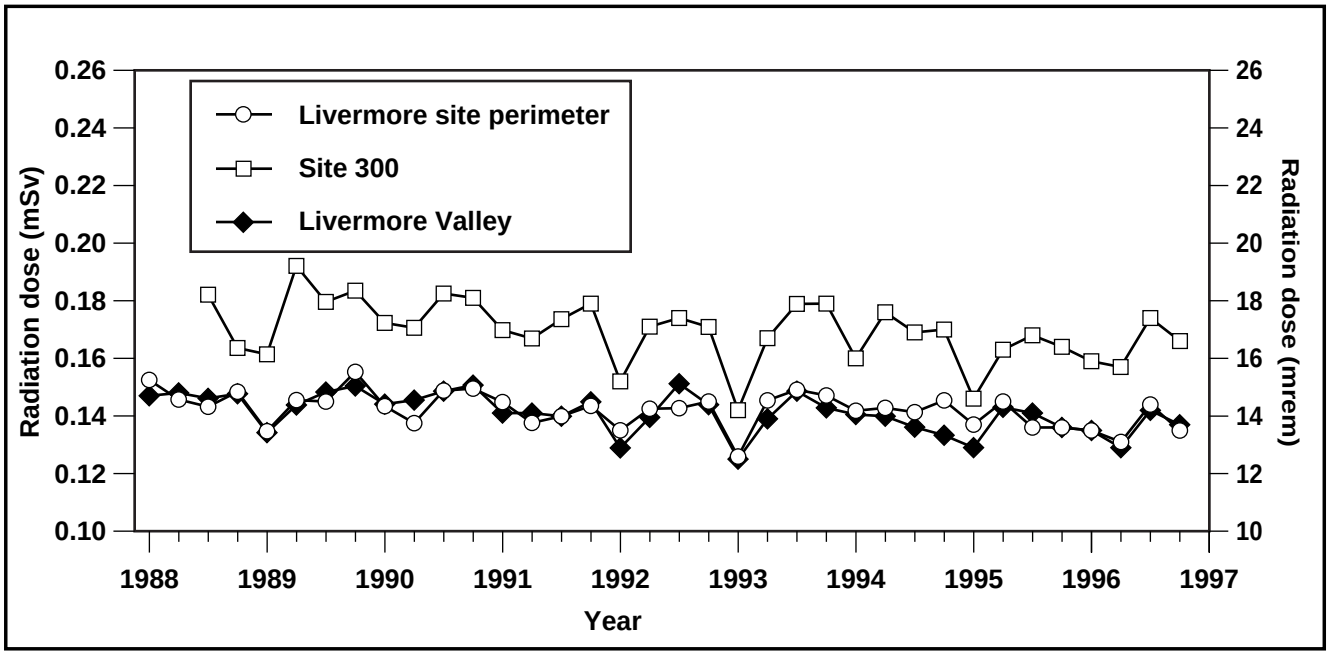

Figure 11-4. Gamma measurements at the Livermore site perimeter, Livermore Valley, and Site 300, 1988 to 1996.

Table 11-1. Summary statistics for gamma monitoring at all sites in 1996 (in mSv).[a]

Quarter	Location									
	Livermore site		Livermore Valley		Site 300		Tracy		Off site	
	Mean	Std. dev.	Mean	Std. dev.	Mean	Std. dev.	Mean	Std. dev.	Mean	Std. dev.
First	0.135	0.008	0.135	0.019	0.159	0.019	0.134	0.014	0.171	0.033
Second	0.131	0.009	0.129	0.012	0.157	0.014	—[b]	—[b]	0.167	0.025
Third	0.144	0.011	0.142	0.016	0.174	0.012	0.200	0.109	0.187	0.028
Fourth	0.135	0.010	0.137	0.017	0.166	0.019	0.136	0.010	0.188	0.059
Total	**0.545**		**0.547**		**0.658**		**0.625**		**0.712**	

a 1 mSv = 100 mrem.

b Insufficient data for calculation.

c The total represents annual totals given in Volume II, which accounts for missing data by averaging data given for each site.

Table 11-2. Annual dose by year at the Livermore site perimeter due to direct gamma radiation.[a]

Year	mSv	mrem
1988	0.59	59
1989	0.58	58
1990	0.58	58
1991	0.56	56
1992	0.56	56
1993	0.57	57
1994	0.56	56
1995	0.56	56
1996	0.55	55

[a] Data normalized to standard 90-day quarters (360-day years).

The adjusted doses at the Livermore site perimeter and in the Livermore Valley are comparable and lack significant trend from 1988 to 1996. However, while Site 300 doses are similarly without trend, they continue to measure slightly higher direct gamma doses than the Livermore site and the Livermore Valley, which is expected given the differences in geology between these sites.

In reviewing the trends of the standard quarter data as shown in **Figure 11-4**, it appears that seasonal variation can occur during the rainy season, most likely because of a decrease in radon emanation from the moist soil. As shown in the figure, the variation was absent during the severe drought years in Northern California (1990–1992) but is apparent when rainfall returned to normal (1994–1995) and above-normal levels (1993).

Environmental Impact

Based on past measurements (Lindeken et al. 1973), environmental terrestrial (geologic) radiation doses in the Livermore Valley vary from 0.25 to 0.60 mSv / y (25 to 60 mrem / y). Cosmic radiation, as calculated for the local elevation and geomagnetic latitude according to the data of Lowder and Beck (1966), is about 0.35 mSv / y (35 mrem / y). This combination results in a typical total direct radiation dose level of 0.60 to 0.70 mSv / y (60 to 70 mrem / y); however, local geological and meteorological factors will impact these dose levels. Direct radiation doses measured at the Livermore site perimeter in 1996 are near these predicted values and are statistically equivalent to the Livermore Valley doses, which are considered natural background levels. This indicates that any dose from LLNL operations is not large enough to be seen within the wide range of natural variation in background levels in different locations.

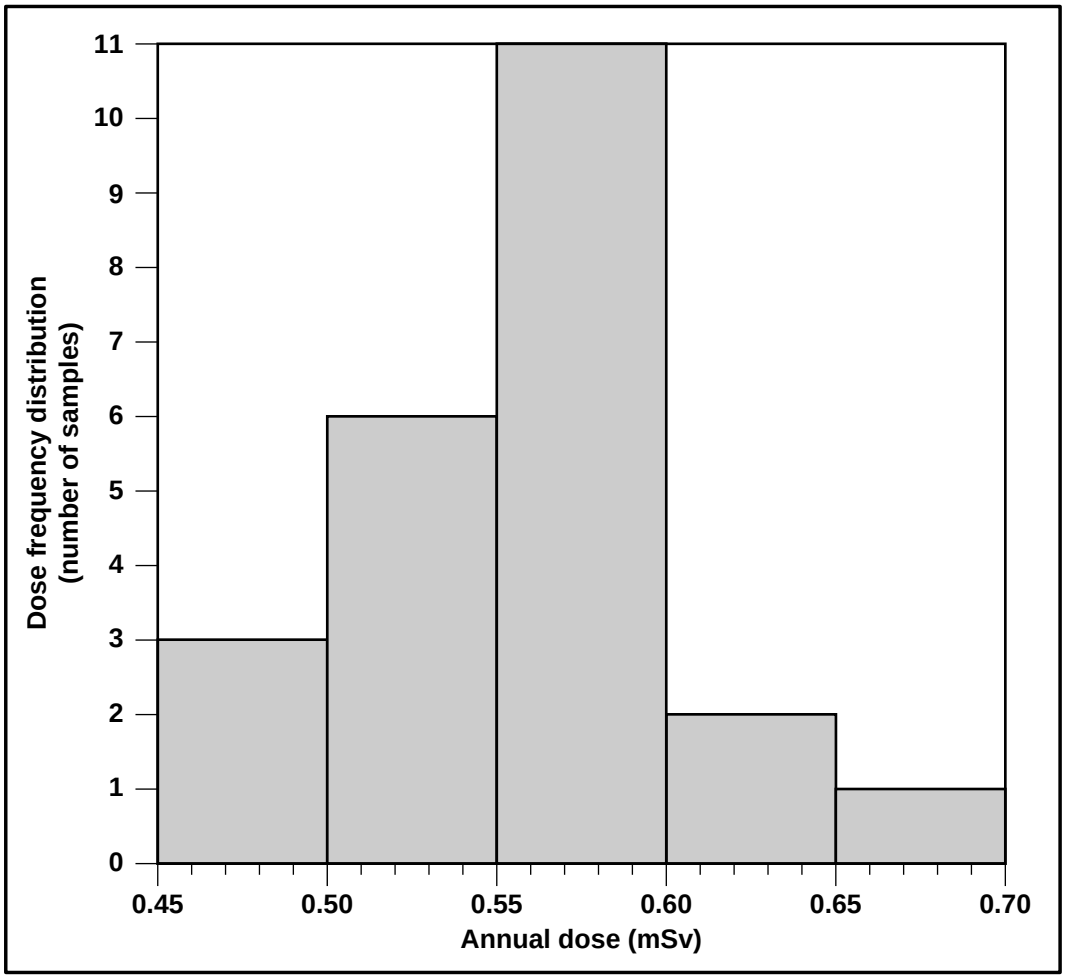

Figure 11-5. Frequency distribution of external gamma radiation at 23 Livermore Valley locations in 1996.